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(RESEARCH ARTICLE)

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Design and fabrication of remote-controlled seed sowing machine

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Abstract

In most countries of which Nigeria is among, Agriculture plays a very vital role in their economic growth. Agriculture is one of the backbones of Nigeria's economy among oil production. It is on this note that farmers are given all the necessary assistance to boost their production. These include provision of good and improved seeds and seedlings, fertilizers and improved implements/equipment for clearing, planting and harvesting to increase their yield.

This research work involves the design and fabrication of remote controlled seed sowing machine to assist local or peasant farmers in seed sowing, thus reducing stress and time wastage involved in the primitive way of planting.

A review of the seed sowing machine was conducted. A design concept was developed and the detailed design was carried out. The machine was manufactured using the secondary manufacturing process and tested for performance. The result showed that the control range of 10m was achieved, the machine can also cover 1000 square meter in 5 minutes and its efficiency is 95 percent.

Keywords: Seed; Sowing; Fabrication; Design; Efficiency

1. Introduction

Agriculture plays a vital role in the Nigeria's economy and is attributed to be the highest employer of labour [2]. Generally, agricultural production can be classified into animal husbandry and crop production [1].

The planting operation is one of the most important cultural practices associated with crop production. Increases in crop yield, cropping reliability, cropping frequency and crop returns all depend on the uniform and timely establishment of optimum plant populations [6].

This research work seeks to develop a remote-controlled seed sowing machine for planting of crops such as maize, beans, and other grains. This machine consists of a 433MHz transmitter and receiver for control of the sowing machine, three drive motors mounted on a metal chassis, a hopper and a discharge outlet, a seed sowing disc, a harrower for opening up soil for seed placement and a hole closer.

2. Review of Related Works

2.1. Manually Operated Template Row Planter

In the work of [1], a manually operated template row planter was designed and developed to improve planting efficiency and reduce tediousness involved in manual planting method. Also, it increased seed planting, seed/fertilizer placement

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accuracy and it was made of durable and cheap material affordable for the small scale peasant farmers. The operating, adjusting and maintaining principles were made simple for effective handling by unskilled operators (farmers). The planting rate of the template row planter was found to be 0.20ha/h. Template seed filling efficiency increases when the walking speed of the planter is 2.16km/h.

2.2. Manually Operated Multi-Crop Planter

[7], worked on the design and fabrication of a manually operated planter sowing for different seeds. It is cheap, easy to maintain and less laborious to use. The multi-crop planter has the capability of delivering the seeds precisely with uniform depth in the furrow, and also with uniform spacing between the seeds. The seed planter consists of the main frame, adjustable handle, seed hopper, seed metering device, adjustable furrow opener, adjustable furrow closer, drive wheels, seed tube and ball bearings. Most of these were fabricated from mild steel material, except for the metering mechanism which was made from good quality nylon and the seed funnel tube, was made from rubber material. Seed metering device was designed to be interchangeable to allow for the different varieties and types of seeds. The single-row manually operated multi-crop planter is very simple to use, the various adjustments are made with ease, and has a reasonable efficiency.

2.3. Tractor Drawn Soya bean Planter

[5], worked on the design and fabrication of a tractor drawn Soya bean planter which was tested in the DESFABENG Company Limited, Bida, Niger State. The major components of the developed planter are three drums with predetermined hole sizes at the exterior ends, a central rectangular shaft, spring soil openers, roller soil cover-er, tractor hitching points, two wheels and power transmission mechanism and frame. All these components were fabricated with locally available materials. Using three test speeds, the planter was preliminarily assessed for seed rate, soil opening, and covering and germination efficiencies. Results obtained indicate that desirable seed rate values of 47.7 and 61.2 kg/ha were observed for tractor/implement speeds of 20 and 16 km/hr, respectively. The highest germination efficiency of the planter was 81.3% at tractor/implement speed of 16 km/hr with corresponding soil opening efficiency of 94%.

3. Material and methods

3.1. Materials

The materials used for this research work were carefully selected based on three considerations/requirements

- Fabrication requirement which refers to the machinability and weldability of the materials.
- Economic requirement which is Paramount in any design has to do with cost and availability of the materials.
- Service requirement of the materials which refers to their properties like strength, toughness, malleability, ductility, corrosion resistance, maintenability, etc

Table 1 Summary of the materials selected

Machine parts	Material used	Justification
Hopper	Mild Steel	It has good strength It is affordable It has high resistance to deformation It can be machined easily
Chassis	Mild Steel	Same as in row 1
Harrower	Mild Steel	Same as in row 1
Bearing	High carbon Steel	Has good wear and corrosion resistance. It is also hard and tough.
Seed sowing disc	Stainless steel	It has good tensile strength. It has high resistance to heat and deformation
Tire	Rubber	It has high tear and tensile strength. It has firm grip with the soil.

3.2. Method

3.2.1. Design Considerations

- Control Range: The range of control of the machine is 10 meters.
- Lateral of Stability: The ease of fabrication of the components
- Safety of the operator
- Availability of materials
- Cost of materials
- Simplicity.

3.2.2. Detailed Design

Design of the Hopper

- Hopper

It stores the seeds to be sown in the soil. The higher the capacity of the hopper, the lesser the time needed to refill the hopper during planting.

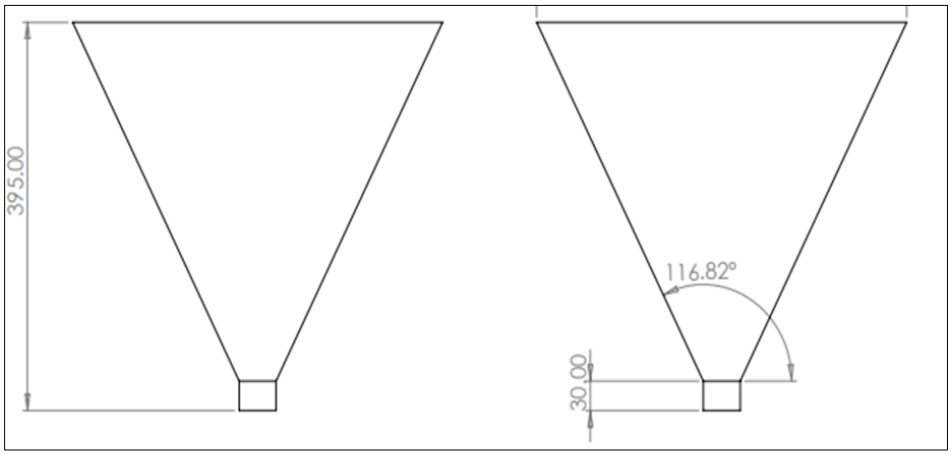


Figure 1 Front view of the hopper

$$V_s = (B \times H \times L) - (X \times H \times L)$$

$$V_s = H \times L(B - X) \text{ - - - - - - - - 1}$$

Where,

$V_s =$ Volume of seed

$Breath(B) = 30cm$

$Height(H) = 40cm$

$Length(L) = 30cm$

$X = 18cm$

$$V_s = 40 \times 30(30 - 18) = 14400cm^3 = 0.0144m^3$$

$$Densityofbean(\rho_b) = 1207kg/m^3$$

$$Mass of bean(M_b) = \rho_b \times V_s \quad - \quad - \quad - \quad - \quad - \quad - \quad 2$$

$$M_b = 1207 \times 0.0144 = 17.38kg$$

$$Weight of beans(W_b) = M_b \times g \quad - \quad - \quad - \quad - \quad - \quad 3$$

$$W_b = 17.38 \times 9.81 = 170.5N$$

$$Volume of plate(V_p) = \frac{1}{2}(B + y)H \times t \quad - \quad - \quad - \quad - \quad 4$$

$$Where, t = thickness = 0.8cm$$

$$y = 5cm$$

$$Volume\ of\ plate(V_p) = \frac{1}{2}(30 + 5)40 \times 0.8 = 560cm^3$$

$$Number\ of\ plate = 4$$

$$Volume\ of\ overall\ plate(V_o) = 4V_p = 4 \times 560 = 2240cm^3$$

$$Density\ of\ mild\ steel(\rho_{ms}) = 7850kg/m^3$$

$$Mass\ of\ mild\ steel(M_{ms}) = \rho_{ms} \times V_o$$

$$M_{ms} = 7850 \times 0.00224 = 17.58kg$$

$$Weight\ of\ mild\ steel(W_{ms}) = M_{ms} \times g$$

$$W_{ms} = 17.58 \times 9.81 = 172.5N$$

$$Weight\ of\ battery(W_B) = 49.05N$$

$$Total\ weight(W_T) = W_p + W_b + W_B$$

$$Total\ weight(W_T) = 172.5 + 170.5 + 49.05 = 392.1N$$

Design of the Chassis

This is the frame that carries the entire weight. Modelling it as a centrally loaded beam and using the stress equation.

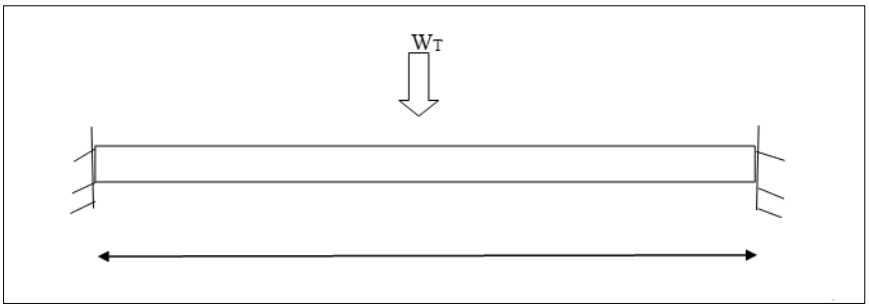


Figure 2 The Chassis

$$I = \frac{FL^3}{192E\delta}[9] \quad - \quad - \quad - \quad - \quad - \quad 5$$

$$Where,$$

$$Length\ of\ the\ chassis(L) = 1.115m$$

$$F = W_T$$

$$E = 207 \times 10^9\ {}^{N}/_{m^2}$$

$$\delta = 1.29 \times 10^{-4}m$$

$$I = \frac{392.1 \times 1.115^3}{192 \times 207 \times 10^9 \times 1.29 \times 10^{-4}}$$

$$I = 1.06 \times 10^{-6}m^4$$

A square pipe was selected.

Design of the Sowing Disc

Using an average size of a bean seed of 1.1cm, for three seeds, total size equals 3.3cm. Therefore a hole of 3.5cm diameter (seed outlet) is created on the disc of 17.1cm diameter so that three seeds can be planted at a time.

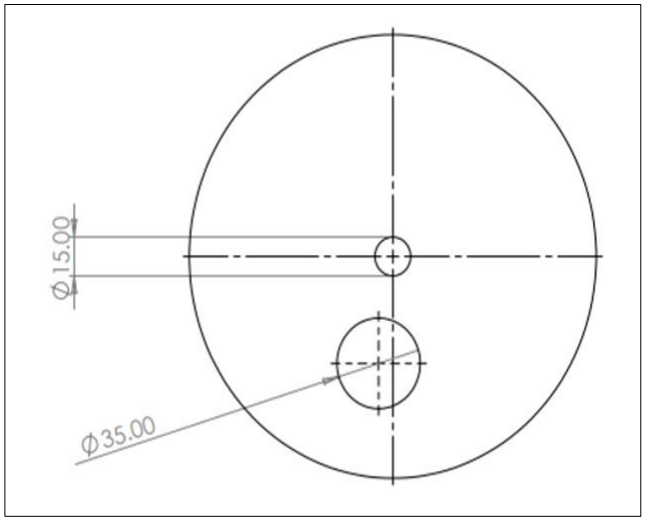


Figure 3 Seed sowing disc

Harrower

The harrower opens up the soil so that the seeds can be planted. Using the stress equation

$$Stress(\sigma) = \frac{My}{I} = (\frac{F \times L \times y}{I})[8] \quad - - \quad - \quad - \quad - \quad - \quad 6$$

Considering a resistance force of 5N, l = 215mm, y = 10mm, for mild steel, stress= 310 N/mm^2 [4]

From equation 6, $I = \frac{F \times I \times y}{\sigma}$

$$I = \frac{5 \times 215 \times 10}{310} = 34.7mm^4$$

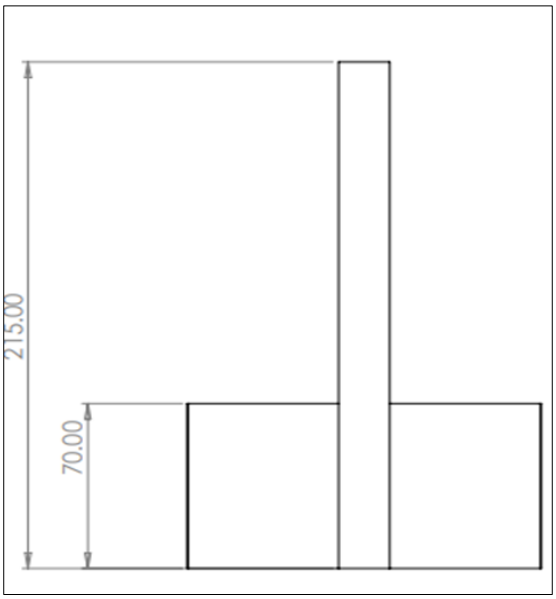


Figure 4 Front view of the Harrower

Bearing Selection

The bearing selected for this work is the deep-groove type because of its advantages which include, (a) it is easy to lubricate (b) It is sample and available. (c) it is easy to replace

$$C/_P = 10.3$$

$$C = 10.3 \times P$$

$$P = 1 \times F_r = 392.1N$$

$$C = 10.3 \times 392.1 = 4038.63N$$

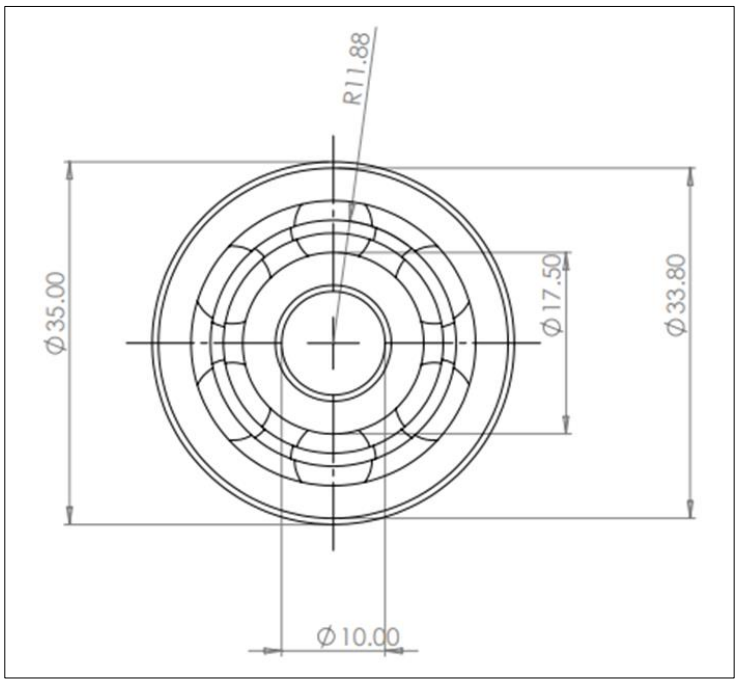


Figure 5 Front view of bearing

Tire Selection

A tubed tire of 0.114m was selected because of its stability.

Figure 6 Tire

Drive Motor Selection

$Torque = F \times r$ [3] - - - - - - - 7

Where:

$F = m \times g$ - - - - - - - - - 8

m = mass of bean, hopper and chassis = 17.38 + 17.58 +15 = 49.96kg

From equation 8, F = 49.96 × 9.81 = 490.108N

r = radius for wheels=0.114m

T = 490.108 × 0.114 = 56Nm

Therefore the motor torque must exceed 56Nm

Table 2 Electric Motor Specifications

Voltage	12v
Starting current	10A
Electrical Power	120watts
Speed	150rpm
Weight	0.7kg
Color	Black
Rotor diameter	8mm
Torque	40Nm
Gear ratio	2/110

Figure 7 Electric Motor

From the above motor specification, three motors were used.

Battery Selection

The battery is carefully selected to provide the electrical power required to operate the machine. From the motor specification, it has a power rating of 120 Watts. Therefore for three motors, the power rating will be 360 Watts.

Thus, a battery of the following specification was chosen.

Table 3 Battery Specifications

Voltage	12V
Current Rating	75A

Figure 8 Battery

Solar Panel Selection

Considering the total power consumption, the rating of solar panel has to be carefully determined.

Table 4 Solar Panel Specifications

S/n	Quantity	Value	Unit
1	Voltage	12	V
2	Current rating	10	A

3.3. Communication Type

Control of the seed sowing machine is to be wireless. Considering a range of 10m, a 433MHz transmitter and receiver module was selected.

3.4. Fabrication Procedure

Fabrication of the seed sowing machine is done in parts. The hopper is fabricated from 16guage steel sheets and 12mm steel rod. The machine chassis is fabricated from 25.4mm square pipe. A welding machine, hack saw, square, vice and angle grinder were used.

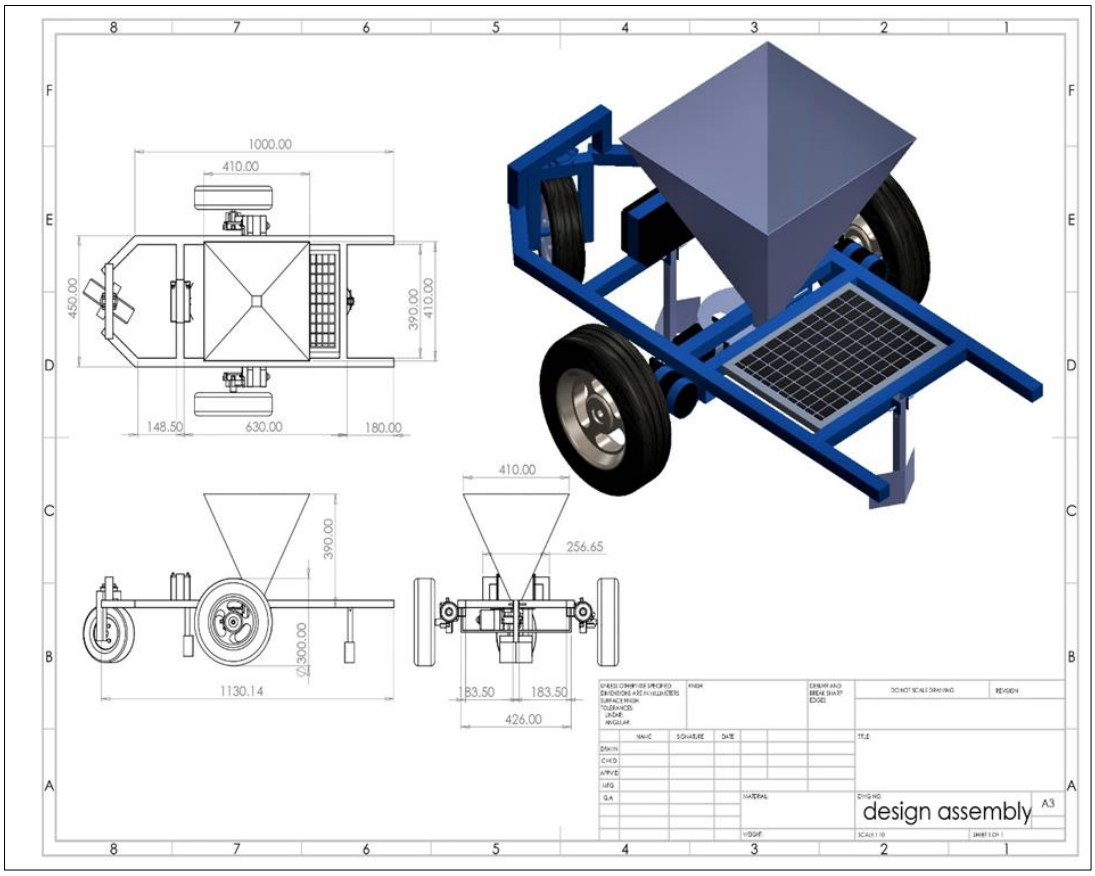
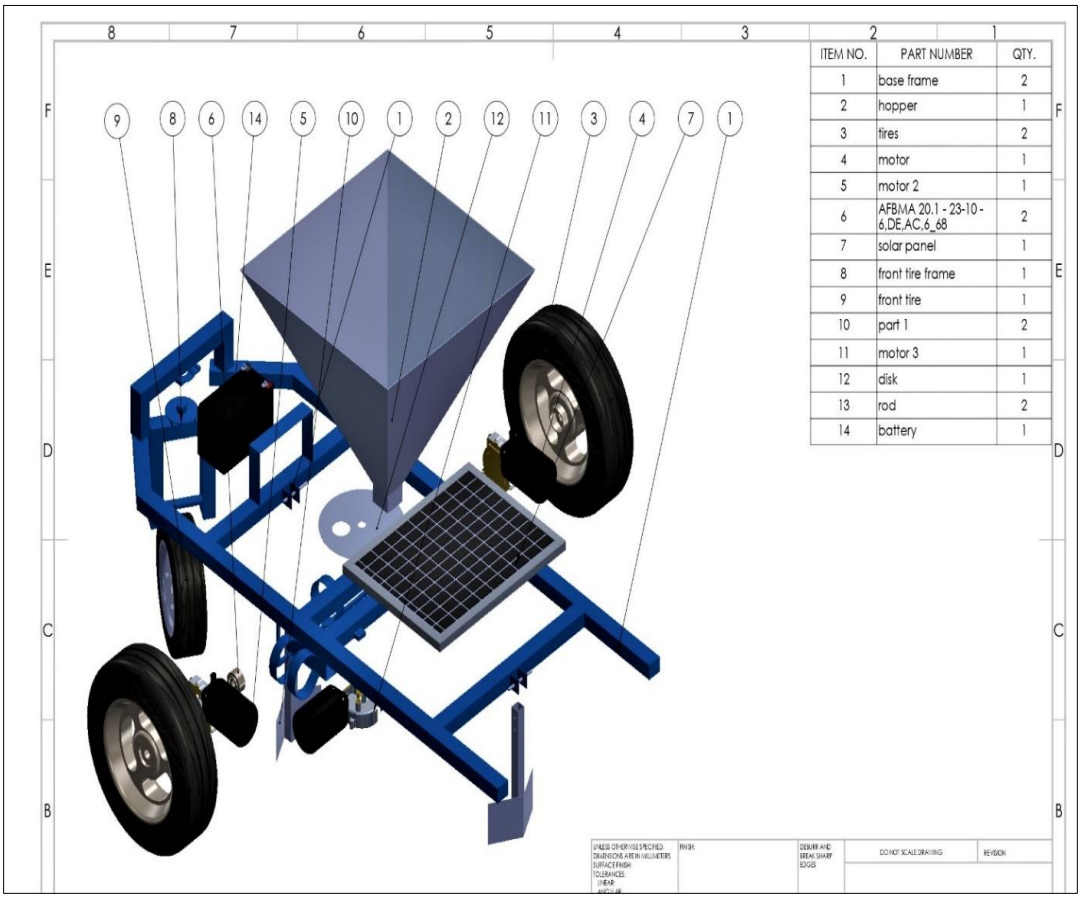


Figure 9 The Three Views of the Machine

Figure 10 Picture of the Fabricated Machine



ITEM NO.	PART NUMBER	QTY.
1	base frame	2
2	hopper	1
3	tires	2
4	motor	1
5	motor 2	1
6	AFBMA 20.1 - 23-10 - 6,DE,AC,6_68	2
7	solar panel	1
8	front tire frame	1
9	front tire	1
10	part 1	2
11	motor 3	1
12	disk	1
13	rod	2
14	battery	1

Figure 11 Exploded View of the Machine

4. Results

Table 5 Response to Control Input

Distance from Machine [m]	Response
2	Fast
4	Fast
6	Fast
8	Fast
10	Fast
11	Fast
12	Delayed
14	Distorted
15	No response

Table 6 Machine Performance

Time (minutes)	Area Covered by Seed Planter(m^2)
5	1000
10	2000
20	4000

5. Discussion

During operation, the machine responded correctly to signals sent from the remote control. It was found that the range of response exceeded the initial designed range of 10m as a fast response was still achieved at 11m and delayed response at 12m. At 14m however, the response received was distorted. When testing was done at 15m, no response was received from the robot thus, the maximum desired response was recorded at 11m. From the table, the machine will cover 1.2 hectares in one hour

5.1. Performance of the machine

For five minutes planting, 950m^2 received seeds out of 1000m^2

$$\text{Efficiency of the machine } = \frac{\text{Area of the soil that received seeds}}{\text{Area covered by the machie}} \times \frac{100}{1}$$

$$\text{Efficiency of the machine } = \frac{950}{1000} \times 100 = 95\%$$

6. Conclusion

In this work, a seed sowing machine was fabricated using locally sourced materials such as mild steel and stainless steel. The machine responded positively even with 1m above the designated range which showed a level of efficiency in its response. It also covers a reasonable planting area in a short while, discharging seeds appropriately. The machine will enhance mechanized farming because it can cover larger areas in few minutes with high level of accuracy. The machine also reduces stress on the operator since he is not pushing it manually.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

All authors declare that there is no conflict of interest regarding the publication of this paper.

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